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TELEPHONE TRAFFIC

CONTENTS

1. GENERAL

1.01 This section is intended to provide REA borrowers, consulting engineers and other interested parties with technical information for use in the design and construction of REA borrowers' telephone systems. It relates specifically to the calls made over a telephone system and the subjects generally included in the term "telephone traffic."

1.02 This issue replaces REA Telephone Engineering and Construction Manual Section 501, "Telephone Traffic - Qualitative Discussion", and Section 505, "Telephone Traffic - Terminology and Calculations." The purpose of the replacement is to coordinate the material contained in the two former sections and to present a more complete picture of traffic considerations and their application to the design of a telephone system. Sections 501 and 505 should be removed from the manual.

1.03 The term "traffic", as used in the design of telephone systems, includes the number, kind, destination and duration of telephone calls, projections of the data to a future period and use of this information in the design of the central office equipment and trunk plant. The term "traffic" also is commonly used to designate the telephone calls offered or handled as the "traffic" on a trunk group.

1.04 The amount of central office equipment and the number of lines and trunks required for a telephone system are determined by the number of subscribers, the party line development, the number, kind and duration of the calls the subscribers make and by the desired grade of service. Quantities of some items of plant such as subscribers' lines, linefinder terminals and connector terminals are determined by the number of subscribers and the parties per line. Other items, such as linefinders, selectors, connectors and trunks, are determined by the number of calls subscribers make, by the length of time they talk and by the grade of service. The design of the items in this second group depends on traffic considerations. The understanding and application of the principles discussed in this and other traffic sections of the REA Telephone Engineering and Construction Manual is important in determining the grade of service to be rendered by a telephone system, the amount of the central office equipment and the number of interoffice trunks required.

1.05 For more detailed information on traffic subjects refer to sections of the REA Telephone and Construction Manual in the 500 series and to Section 156, "Nationwide Toll Dialing"; Section 157, "Customer Toll Dialing"; and Section 325, "Application Guide for the Preparation of Detail Dial Central Office Equipment Requirements."

2. NATURE OF TELEPHONE TRAFFIC

2.01 Telephone users place calls at random throughout the 24 hours of the day, and the length of the time they talk varies from a few seconds to many minutes. However, there is one hour in the day during which more calls are placed than in any other. This is known as the "busy hour", and it is the general practice to provide facilities on the basis of the traffic level in the busy hour. Also, the average duration of telephone calls of a particular type is fairly constant and this average, known as the "holding time", enters into the calculation of central office equipment and trunk requirements.

2.02 The product of calls per hour and average holding time gives the total time that a particular facility is in use or the "usage" during the hour. For example, if a trunk group carries 75 calls in the busy hour with an average holding time per call of 150 seconds, the usage on the group is 75 x 150 or 11,250 seconds. The generally accepted unit of measure for this item is a "unit call" (UC) of 100 seconds. A total usage of 11,250

seconds would be expressed as 112.5 UC. The term "CCS" also is used and is equivalent to unit calls. The term "erlang", which is equal to 36 UC or 36 CCS is another unit of measure of usage generally employed outside the U.S.A.

2.03 In the design of telephone systems the basic estimate of size usually is the number of lines to be served. To develop the amount of traffic to be handled the "call rate" per line is estimated. This generally is expressed in terms of unit calls per line or total calls per station. When the call rate is expressed in unit calls per line, this figure, multiplied by the number of lines, gives the traffic volume or total unit calls which the switching equipment must handle.

2.04 At any given instant, even during the busy hour, only a small percentage of the subscribers in an exchange will be using their telephones. Consequently, it is practical to provide switches and trunks, that is "paths", for the calls on the basis of busy hour usage rather than on the basis of the number of subscribers connected. Enough equipment and trunks must be provided so that a customer will encounter dial tone delay or a paths-busy signal on only a small percentage of his calls.

2.05 Telephone traffic also varies from day to day and seasonally. In most offices, traffic is greater from Monday through Friday than over the weekend. Similarly, most offices experience a busy season during which traffic is greater than during other periods of the year. To provide a satisfactory grade of service, it is considered necessary to engineer for the traffic in the busy hour on an average business day during the busy season. There will be some days, such as just before Christmas, on some special occasions, or when a storm affects a high percentage of subscribers, when traffic volume may greatly exceed the figure for which facilities were provided. It is not practical to provide equipment or trunks for such peaks and the result is that customers have to wait longer for dial tone and encounter more paths-busy conditions. However, in a well designed system service should not fail entirely even during severe overloads.

2.06 There are different kinds of telephone calls such as local, toll, EAS and information. Toll calls are further divided into station-to-station, person-to-person and other classes. The central office equipment is involved in every call and the amount of equipment provided is based on the total usage for all types of calls. On the other hand, separate trunk groups usually are provided for EAS and toll traffic and in the larger offices for

information and other classes. For such groups, the number of calls and the average holding time for each type handled are the major factors in determining trunk requirements. The average call holding time ranges from perhaps 20 seconds on information to 350 or 400 seconds on toll calls.

2.07 Another characteristic of telephone traffic is the temporary nature of telephone connections. They can be measured only while they are in progress. This makes it necessary to measure traffic volume regularly in the busy hour during the busy season if the right amount of central office equipment and the correct number of trunks are to be provided when making additions to a telephone system.

3. TRAFFIC OPERATING ARRANGEMENTS

3.01 Traffic operating arrangements include such items as numbering plans, switching plans, interoffice trunk layouts, use of digit absorbing selectors, customer or operator toll dialing, tributary or toll center operation, direct or common control switching systems, etc.

3.02 Dial central office equipment may be either "direct control" or "common control" which, in effect, are different operating arrangements. In direct control systems such as step-by-step, each selector (and connector) responds directly to the dial pulses from the user's telephone. In common control systems, the pulses are stored in a register which in turn actuates the various selectors to establish the connection to the desired number. The determination of quantities of equipment and arrangement of selectors is substantially different for the two systems.

3.03 In designing a telephone system, there usually is a choice between several operating arrangements, any of which would provide good service. The principal objectives to be kept in mind are minimum cost, simplicity of operation for customer, and suitability for expansion. The various traffic sections of the REA Telephone Engineering and Construction Manual describe the operating arrangements available and their fields of application.

4. GRADE OF SERVICE

4.01 There are two measures of telephone service which are directly affected by the amount of central office equipment and the number of trunks provided. The first, speed of dial tone,

usually is expressed as the percentage of attempts on which the users waits longer than three seconds for dial tone. The second is the percentage of calls delayed due to a paths-busy condition.

4.02 Equipment usually is engineered to give a speed of dial tone of 1.5 percent of attempts with dial tone delayed in excess of three seconds. This applies to the busy hour of the busy season in the year for which the equipment is engineered. Since telephone equipment usually is engineered for several years in the future, it is evident why dial tone delays under normal operating conditions are rare.

4.03 Once a customer has begun dialing, any paths-busy condition blocks the call, a paths-busy signal is returned and the customer has to hang up and place his call later. The grade of service under these conditions is expressed in terms of the probable percentage of calls that are delayed. For example, a grade of service of one delayed call in a hundred is expressed as P = .01. A delay of 10 in 100 is indicated as P = .10.

4.04 As in the case of dial tone speed, central office equipment and trunks are engineered for a particular probability of delay, such as P = .01, for the busy hour of the busy season in some future years. Central office equipment usually is engineered on the basis of P = .01 to P = .03 per stage of selection, interoffice trunks on the basis of P = .03 to P = .10.

4.05 Central office equipment and interoffice trunks are engineered on the basis of a specific grade of service by means of tables that show the number of unit calls that can be handled by a trunk group of a given size with a given probability of delay. Following is an example of a table with a probability of delay of P = .01 and full access of calls to all trunks. (REA TE & CM-510, "Telephone Traffic - Dial Central Office Switch Quantities.")

Number of Trunks	Capacity in Unit Calls per Hour
2	5.4
3	15.7
4	29.6
5	46.1
10	149
20	351

4.06 The grade of service also is affected by the number of paths to which a call has access. For example, with full access, a load of 351 unit calls would require 20 trunks as shown on the preceding table. However, if the design of the equipment

is such that a call has access to only 10 trunks and 351 unit calls are offered, two groups of 10 trunks each would handle only (2 x 149) or 298 unit calls. Either there will be more delays than 1 in 100 or more trunks have to be provided. Most step-by-step dial systems provide access to a maximum of 10 trunks and tables have to be used that take this factor into account. In practice, an arrangement known as "grading" is used under such circumstances which increases the capacity above that obtainable from two separate trunk groups but not up to the capacity of a "full access" group. This is described in REA TE & CM-510.

4.07 In practice, the grade of service actually received by a telephone user may differ widely from the probability of delay for which the central office or a trunk group were engineered. The calls in a particular busy hour may be more or less than estimated, their average holding time may be different, their distribution during the hour may include one or more sharp peaks, some groups of linefinders or connectors may be over or underloaded, or some of the equipment may be temporarily out of service. However, experience shows that over a period of time the average percentage of delays for a given traffic volume and a given size of trunk group closely follows the figures of the tables which were derived from mathematical theories of probability.

5. ESTIMATING TRAFFIC VOLUME

5.01 Estimates of traffic volume are the first requirement in determining the amount of central office equipment and the number of trunks to be provided. Such estimates are based on the actual traffic volume in the existing office or on average unit calls per line as developed for general use.

5.02 When a magneto office is to be replaced by dial, any existing date on local traffic volume are of little value in forecasting future traffic on account of the complete change in operation. Under such circumstances, or when a telephone office is opened in new territory, average figures of unit calls per telephone for different classes of service are used as described in REA TE & CM-325, "Application Guide for the Preparation of Detail Dial Central Office Equipment Requirements."

5.03 When an addition is to be made to a dial office or to an interoffice trunk group, actual figures on busy hour, busy season traffic usage of equipment and trunks offer the most

dependable basis for determining future requirements. For this reason, it is important to measure the busy hour traffic volume regularly for several days during the busy season.

5.04 Records of toll traffic usually are available for existing offices in terms of total messages per month from which the toll calling rate per telephone can be developed. This calling rate may be applied to the estimated number of telephones to develop the estimated toll volume in the future. This can be converted into busy hour unit calls by applying suitable ratios of business days per month, percent busy hour and holding time.

5.05 In converting a manual office to dial with a significant increase in telephones, it may be thought that the average toll calls per telephone would decrease. In practice, it has been found that the improvement in service and in transmission that goes with the usual dial conversion results in more use of the toll service by the original subscribers. The use of the current toll calling rate, corrected for any conversions to EAS, with the estimated number of telephones at the end of five years has been found fairly dependable for the initial estimate of toll trunk requirements. However, soon after a new office is placed in service it is advisable to obtain usage data to check the adequacy of the trunks provided and it is well to do this regularly during the busy season.

5.06 Estimating EAS traffic volume is one of the most difficult problems in the design of telephone systems. Where toll service between two offices is being replaced with EAS, increases of three to five-fold may be expected, depending on the previous toll rate and the community of interes
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5.07 In designing a new telephone
system with dial, estimates
be relied upon as being very

in the various sections of the REA Telephone Engineering and Construction Manual are based on experience and have been found satisfactory for initial installations. However, it cannot be overemphasized that the actual traffic volume after an office is placed in service needs to be measured to make sure that the original estimates were reasonable. Major shortages or unbalance between groups may have to be corrected at once. In any case, actual traffic usage data are the only sound basis for engineering additions to central office equipment or interoffice trunk groups.

6. CALCULATION OF SWITCH AND TRUNK QUANTITIES

6.01 Having developed an estimate of the traffic volume, it is a simple matter to refer to the appropriate table and determine the number of selectors or trunks required. For example, a toll traffic estimate of 86.5 unit calls, with a probability of delay of P = .03, would require seven trunks. See REA TE & CM-510, Figure 2A.

6.02 For interoffice trunks, different delay tables are used depending on whether the group handles toll or EAS traffic and on the length of haul. For central office equipment quantities, however, tables have been provided for use in all offices which will assure a satisfactory grade of service without excess equipment. (See REA TE & CM Sections 510, 511 and 520, and REA Form 558a, General Specifications.)

6.03 The delay tables provided in the various sections of the Telephone Engineering and Construction Manual and in the Specifications are derived from mathematical formulas based on the theory of probability and are the same as those in general use in the industry.

7. CALCULATION OF TOLL AND INFORMATION POSITIONS

7.01 For the relatively small toll switchboards required in the toll centers of REA borrowers, it has been found satisfactory to base the position requirements on the number of toll messages completed per day. The procedure is described in REA TE & CM-512, "Telephone Traffic - Manual Toll Board Equipment", and in Section 157, "Customer Toll Dialing."

7.02 It is the usual practice in toll centers to maintain a daily record of toll messages. Once a toll office is in operation experience will show how many toll messages per day per

position can be handled and maintain a satisfactory speed of answer to trunk signals. This can be used as a basis for future requirements and for additions to existing offices.

7.03 In most of the smaller toll offices, information calls are handled on one or two end positions of the toll board along with some toll calls. The work of handling such information traffic, as well as the occasional assistance, intercepting and other miscellaneous calls, is usually considered a part of the toll job. As long as this work is a relatively small portion of the total operating load, the use of toll messages per position as a measure of position requirements is sufficiently accurate in small toll offices.